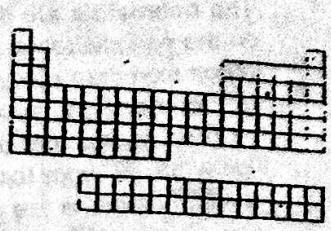
Class _____ Date _____

Metals



On the periodic table, all but one of the elements to the left of the zigzag line are called **metals**. Hydrogen (H) is the only exception; it is considered a nonmetal. Metals have similar properties. They are usually hard, shiny, have high densities, and high melting points. Most metals are solids at room temperature. Mercury (Hg) is a liquid at room temperature (25°C). Cesium (Cs), francium (Fr), and gallium (Ga) melt at temperatures slightly warmer than 25°C. There are no metallic gases. Because solid metals are malleable, they can be hammered or bent into shapes. They are also ductile and can be pulled or stretched into thin wires. Metals are also generally good conductors of electricity and heat.

As you have learned, most metals have one, two, or three electrons in their highest occupied energy levels. These valence electrons are held loosely. Metals tend to give up valence electrons to form ionic bonds with other elements. However, neutral metal atoms form a special kind of bond among themselves, called a **metallic bond**. In metals, the loosely held valence electrons form a kind of cloud around the atoms. The atoms share the electrons. This makes the metallic bond. In metals, the valence electrons are free to move about. When an electric current or heat touches a metal, the electrons can move away from the atoms they are nearest. The moving electrons pass, or conduct, the electric current or heat from one atom to the next. The loosely held valence electrons allow atoms to slide past each other. That is why a metal can be hammered or stretched without breaking. In a nonmetal, valence electrons are more tightly held by the atoms. Atoms in nonmetals cannot slide past each other easily. When a solid nonmetal is hammered or stretched, its atoms are pushed closer to each other. The atoms repel each other, and the nonmetal breaks.

Review Questions

Review the information you have been given about the metals. Then read the following questions and fill in the blanks using the answers below. (Not all of the answers will be used.) Write the answers on the blanks in the right column.

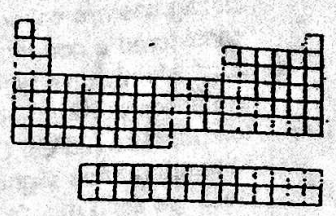
brittle	liquid	three	helium	malleable
hydrogen	nonconductors	metallic	conductors	ductile

1. A substance that can be stretched into thin wires is called ___a___.
2. Although most metals are not ___b___ at room temperature, the element mercury (Hg) is.
3. Metals are good ___c___ of heat and electricity.
4. The special bond between atoms of metals is called a ___d___ bond.

a. DUCTILE
b. LIQUIDS
c. CONDUCTORS
d. METALLIC

Name _____ Class _____ Date _____

Nonmetals



The **nonmetals** are the group of elements to the right of the zigzag line on the periodic table, plus hydrogen. Nonmetals have fewer properties in common than metals. Their most common characteristic is that they are *not* metals. They are not malleable, ductile, or shiny, and they are not good conductors of heat or electricity. In fact, they are used as insulators. At room temperature, some nonmetals are solids, some are liquids, and some are gases.

Most nonmetals have five to eight electrons in their highest occupied energy levels. (Boron, carbon, and silicon are the exceptions.) As a result, nonmetals hold their valence electrons tightly. Some nonmetals form covalent bonds by sharing electrons. The atoms of most nonmetals can accept electrons, become ions, and form ionic bonds. Nonmetals are good insulators because they hold their valence electrons so tightly.

The noble gases, 8A (18), are a special group of nonmetals. All but one of these gases have eight valence electrons. Helium (He) is the exception with two electrons in one energy level. This electron arrangement makes these atoms very stable. The noble gases do not react very easily with other elements or even themselves. Thus, they are considered "safe" gases. They are used in advertising signs (neon and argon), balloons (helium), and even blimps (helium).

Review Questions

Review the information you have been given about nonmetals. Then read the following questions and fill in each blank at the right with the letter of the correct answer. (You will need to use the periodic table.)

1. Which of the following is a property of a nonmetal? 1. NON CONDUCTOR
   a) malleable b) nonconductor c) ductile d) shiny
2. Which of the following elements is a nonmetal? 2. BROMINE
   a) Na b) Br c) Mg d) Li
3. A noble gas used in advertising signs is _____. 3. NEON
   a) Xe b) He c) Kr d) Ne
4. A nonmetal with six valence electrons is _____. 4. OXYGEN
   a) O b) N c) F d) Cl
5. Most nonmetals have _____ or more valence electrons. 5. FIVE
   a) three b) two c) five d) four
6. Helium is a noble gas with _____ electrons in one energy level. 6. TWO
   a) three b) two c) eight d) six
7. Which of the following elements is a nonmetal? 7. CARBON
   a) C b) Fe c) Na d) Rb

Name _____ Class _____ Date _____

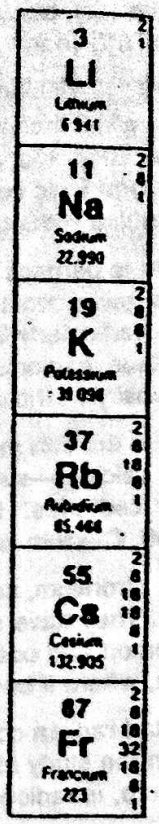
Alkali Metals Group

The alkali metals are members of Group 1A (1) of the periodic table. They include lithium (Li), sodium (Na), potassium (K), rubidium (Rb), cesium (Cs), and francium (Fr). These elements are very good conductors of heat and electricity. They are soft and can be cut easily with a knife. Group 1A (1) elements have low melting points, ranging from 180°C (lithium) to 28°C (cesium). They also have low densities, ranging from 0.53 g/cm^3 (lithium) to 1.90 g/cm^3 (cesium).

The alkali metals are the most chemically reactive metals. They are so reactive that they are never found free in nature. Pure samples of alkali metals are stored in oil so that they cannot react with oxygen or water in the air. Alkali metals usually form ionic compounds. Each alkali metal atom has one electron in its highest energy level. This loosely held electron can easily combine with a nonmetal atom to form a pair of ions. These ions then form an ionic compound.

The ions of the alkali metals can be identified by using the flame test: A small amount of an unknown metal in an ionic compound is heated in a flame. The color of the flame indicates which metal ion is present. For example, sodium's flame is bright yellow, and potassium's is pale pink.

Alkali metals are used to produce chemicals, metals, soap, glass, ceramics, petroleum products, and textiles. Cesium and rubidium are used in photoelectric cells. Potassium—in the form of potassium carbonate, or potash—is used as plant fertilizer. Sodium, combined with chlorine to form sodium chloride (table salt), makes the ocean salty. Potassium and sodium ions are essential for life for most organisms.



Review Questions

Review the information you have been given about the alkali metals. Then read the following paragraph and fill in the blanks, choosing from the words below. (Note: A word may be used more than once. Some words are not used.) Write the letter of each answer on the appropriate blank in the column to the right.

cesium	heat	one	temperature
color	ionic	potassium	three
electricity	molecular	sodium	water

The alkali metals are very good conductors of ___a___ and ___b___. They are extremely reactive and are found in ___c___ compounds. Each atom in the alkali metals group has ___d___ electron(s) in its highest energy level and combines easily with other elements to form ions. Alkali metals can be identified through the flame test, in which each element produces a flame of a different ___e___ ___f___ and ___g___ are necessary ions for life for most organisms.

a. HEAT
b. ELECTRICITY
c. IONIC
d. ONE
e. COLOR
f. SODIUM
g. POTASSIUM

Name _____ Class _____ Date _____

Alkaline Earth Metals Group

The alkaline earth metals are members of Group 2A (2) of the periodic table. They include beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), and radium (Ra). Their melting points range from 1278°C (beryllium) to 650°C (magnesium). Their boiling points range from 2970°C (beryllium) to 1090°C (magnesium).

↑ Than Group 1

Like the alkali metals, the alkaline earth metals are very chemically reactive. They, too, are never found free in nature. Alkaline earth metals usually form ionic compounds. Each atom has two valence electrons that combine with other elements to form ions.

Beryllium is perhaps best known as a part of the mineral beryl. Two precious gems contain beryllium: emerald and aquamarine. Beryllium metal is particularly light and rigid. It is used in computers, gyroscopes, and nuclear reactors. Magnesium is used in aircraft, spacecraft, and in high-intensity flashbulbs.

Calcium is the fifth most abundant element in the earth's crust. Some forms of calcium—such as calcium oxide, or lime—have been known for many centuries. However, pure calcium metal was not discovered until 1808. Calcium is an essential part of teeth and bones.

Calcium, strontium, and barium have many chemical properties in common. They have similar industrial uses. However, strontium is much less common and costs more. One special use of strontium is in fireworks, where it burns with a brilliant red color.

Barium and radium compounds both have special medical uses. Barium is used in the study of digestive disorders. Radium, found in nature in uranium ore, is radioactive and has been used in cancer therapy.

4	2 2
Be	
Beryllium	
9.012	
12	2 8 2
Mg	
Magnesium	
24.305	
20	2 8 8 2
Ca	
Calcium	
40.08	
38	2 8 18 8 2
Sr	
Strontium	
87.62	
56	2 8 18 18 8 2
Ba	
Barium	
137.33	
88	2 8 18 32 18 8 2
Ra	
Radium	
226.025	

Review Questions

Review the information you have been given about the alkaline earth metals. Then read the following paragraph and fill in the blanks at the right, choosing from the words below. (Note: A word may be used more than once. Some words are not used.)

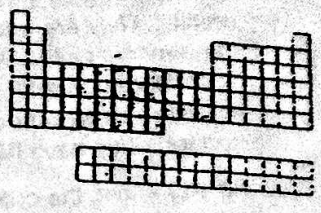
barium	calcium	magnesium	strontium	lower
beryllium	higher	one	two	uranium

Group 2A (2) elements have ___a___ melting points than Group 1A (1) elements. ___b___ has the lowest boiling point in this group, at 1090°C. Alkaline earth metals have ___c___ valence electrons. Emerald and aquamarine contain the element ___d___. ___e___ is the fifth most abundant element in the earth's crust. A flame test for ___f___ yields a brilliant red color. Radium is found in ___g___ ore in nature.

a. HIGHER
b. MAGNESIUM
c. TWO
d. BERYLLIUM
e. CALCIUM
f. STRONTIUM
g. URANIUM

Name _____ Class _____ Date _____

Transition Metals



The transition metals are in Groups 1B through 8B (or 3 through 12) on the periodic table. They include many common metals such as copper, iron, nickel, zinc, chromium, mercury, silver, and gold. Most transition metals are hard and brittle, with high melting points. They form many useful alloys with one another. Many have characteristic colors by which the pure metals and their alloys may be recognized. Most have either one or two electrons in their highest occupied energy level. Many form more than one kind of ion with different amounts of charge. For example, iron forms ions with charges of 2+ (Fe^{2+}) or 3+ (Fe^{3+}).

The properties of the transition metals vary widely. But each element is similar to its nearest neighbors on the periodic table. Most transition metals have a grayish color (silver), but some are yellow (gold) or reddish (copper). A few have low melting points, such as mercury (Hg), at −38.9°C. Many have high melting points, such as tungsten (W), at 3380°C. Osmium (Os) has a density of about 22.5 g/cm^3, but titanium (Ti) has a density of only 4.1 g/cm^3. Many transition metals form cubic crystals, but some form tetragonal or hexagonal crystals.

The many industrial uses of transition metals range from medicines to ornaments, from aircraft parts to thermometers. Three examples to consider are gold (Au), palladium (Pd), and tantalum (Ta). Pure gold is used in the electronics industry. Gold salts are used to treat arthritis. Palladium, a less familiar metal, is used in dentistry. It is also used to make watches and surgical instruments. Tantalum has uses that range from nuclear reactors and missile parts to camera lenses. Tantalum is also used for surgical appliances. It has an unusual ability to resist chemical attack. It will neither break down nor cause irritation within the human body.

Review Questions

Review the information you have been given about the transition metals. Then read the following paragraph and write the answers in the proper blanks, choosing from the words below. (Note: A word may be used more than once. Some words are not used.)

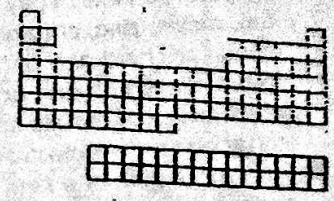
color	low	osmium	tantalum	tungsten	octagonal
cubic	mercury	palladium	titanium	shape	high

Many transition metals have characteristic ___a___s by which pure forms and alloys may be recognized. Some have ___b___ melting points, such as mercury. ___c___ is very dense, at about 22.5 g/cm^3. Many transition metals form ___d___ crystals. ___e___ is a transition metal used in watch manufacture. ___f___ is used to make camera lenses. ___g___ is known to have an unusual ability to resist chemical attack.

a. COLOR
b. LOW
c. OSMIUM
d. CUBIC
e. PALLADIUM
f. TANTALUM
g. TANTALUM

Name _____ Class _____ Date _____

Lanthanide and Actinide Metals



The lanthanides and the actinides are two series of chemically similar metals. They are usually shown as two separate rows at the bottom of the periodic table. All of the elements in the top row, beginning with lanthanum (La) and ending with lutetium (Lu), are lanthanides. The actinides begin with actinium (Ac) and end with lawrencium (Lr). In general, they have high melting points and boiling points.

As you know, the order of the periodic table reflects the arrangement of electrons in energy levels in atoms. Each element differs from the one before by having one more electron. As you move along the periodic table, electrons generally fill higher energy levels. The arrangement of the electrons in the highest occupied energy level gives each element its chemical properties. The lanthanides are similar to one another chemically because their highest occupied energy levels have the same arrangement of electrons. They are unusual in that they have a *lower* energy level holding the extra electrons that make them different from one another.

The lanthanides used to be called "rare earths," but we now know they are not rare. They are used in alloys. Many have magnetic properties. The strongest permanent magnets are made of an alloy of cobalt with the lanthanide samarium (Sm). Europium (Eu), one of the most expensive lanthanides, is used in television tubes.

The actinides are also similar to one another chemically. Both actinides and lanthanides tend to form ions with a 3+ charge. All actinides are radioactive. Some decay so quickly that they must be made synthetically just to be studied. The best known actinide is the metal uranium. The main uses of uranium and other actinides are in nuclear reactors and weapons.

Review Questions

Review the information you have been given about the lanthanide and actinide metals. Then choose the answer that best completes each of the following sentences. Write the letter of each answer on the appropriate blank in the column to the right.

1. The strongest permanent magnets are made of cobalt and _____.
   a) La b) Sm c) Eu d) Yb

2. The _____ used to be called "rare earths."
   a) lanthanides c) actinides
   b) metals d) transition metals

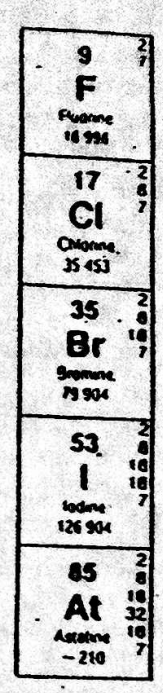
3. The best known _____ is uranium.
   a) actinide c) transition metal
   b) lanthanide d) alkali metal

4. The main use of _____ is in nuclear applications.
   a) lanthanum c) lanthanides
   b) europium d) actinides

1. SAMARIUM (Sm)
2. LANTHANIDES
3. ACTINIDE
4. ACTINIDES

Halogen Group

When we think of salt, we usually think of table salt, or sodium chloride (NaCl). Sodium chloride is made of a metal, sodium (Na), and a halogen, chlorine (Cl). Table salt is actually just one of many salts. Whenever a metal is combined with a member of the halogen group, Group 7A (17), a salt is formed. The word **halogen** actually means "salt former." The halogen group includes fluorine (F), chlorine (Cl), bromine (Br), iodine (I), and astatine (At). Group 7A (17) elements all have seven electrons in their highest occupied energy level.



In nature, the halogens occur only in combination with other elements. Pure halogens are very poisonous. The halogens form ionic bonds with metals. They form covalent bonds with one another and with nonmetals. As gases, the halogens exist as diatomic molecules. Halogen melting points range from −219°C (fluorine) to 302°C (astatine). Boiling points range from −188°C (fluorine) to 337°C (astatine). Group 7A (17) densities are greater than the density of air. They range from 1.6 g/L (fluorine) to 11.2 g/L (iodine).

Of all the elements, fluorine is the most reactive. It is commonly found in the mineral fluorite (CaF_2). Compounds containing fluorine are called fluorides. You may recall that stannous fluoride (SnF_2) prevents tooth decay. The most abundant halogen is chlorine. It is almost as reactive as fluorine. Chlorine is used in bleaches and disinfectants. Bromine is a reddish-brown liquid. It is the only nonmetallic element that is liquid at room temperature. Iodine has many properties that metals have. It is essential for human health. Lack of iodine causes thyroid gland disorders. Astatine, one of the earth's rarest elements, is radioactive. Like polonium, it is usually made synthetically. The total amount of astatine in the earth's crust is thought to be less than 30 grams.

Review Questions

Review the information you have been given about the halogen group. Then choose the answer that best completes each of the following sentences. Write the letter of each answer on the appropriate blank in the column to the right.

1. The most abundant **halogen** is _____.
   a) fluorine b) bromine c) chlorine d) iodine
2. Of all elements, the most reactive is _____.
   a) fluorine b) bromine c) chlorine d) iodine
3. A halogen and a metal combine to form a(n) _____.
   a) covalent compound b) ion c) salt d) gas
4. The only nonmetallic element that is liquid at room temperature is _____.
   a) fluorine b) bromine c) chlorine d) iodine
5. Lack of _____ causes thyroid disorders.
   a) fluorine b) bromine c) chlorine d) iodine

1. CHLORINE
2. FLUORINE
3. SALT
4. BROMINE
5. IODINE

Name _____ Class _____ Date _____

Noble Gases

The noble gases are members of Group 8A (18) on the periodic table. They include helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), and radon (Rn). The noble gases are very unreactive. They are all found free in nature. They do not usually combine with other elements or with one another, but a few compounds can be formed.

Noble gases are monatomic gases. The melting and boiling points of the Group 8A (18) elements increase with increasing atomic mass. The melting points range from −272°C (helium) to −71°C (radon). Boiling points range from −268°C (helium) to −61°C (radon). Noble gas densities range from 0.1 g/L (helium) to 9.7 g/L (radon).

Helium is the second most abundant element in the universe. Only hydrogen is more abundant. The energy of the stars and of the hydrogen bomb comes from the fusion of hydrogen into helium. Lighter than air and safer than hydrogen, helium is also used to fill balloons. Helium is used as a refrigerant commercially and in nuclear reactors. Neon is an even better refrigerant.

Neon, argon, and xenon were discovered by cooling air into a liquid and then separating the liquid into individual elements. Neon's largest use is as a gas for advertising signs. Most of the noble gases are used in advertising signs. Each gas produces a different intense color. Most noble gases are also used in lasers.

The wavelength of the light produced by krypton has been used to define the international standard of the meter. Krypton is used in electron tubes, stroboscopic lights, and bacteria-killing lamps. Radon, the most dense of all gases, is given off when radium decomposes. Radioactive radon is used in cancer treatment.

-2	2	
He		
Helium		
4.003		
10	2	
Ne	8	
Neon		
20.179		
18	2	
Ar	8	
Argon	8	
39.948		
36	2	
Kr	8	
Krypton	18	
83.80	8	
54	2	
Xe	8	
Xenon	18	
131.30	18	
	8	
86	2	
Rn	8	
Radon	18	
~ 222	32	
	18	
	8	

Review Questions

Review the information you have been given about the noble gases. Then read the following paragraph and fill in the blanks, choosing from the words below. (Note: A word may be used more than once. Some words are not used.) Write your answers on the blanks in the column to the right.

argon	hydrogen	neon	triatomic
diatomic	krypton	radon	unreactive
helium	monatomic	reactive	xenon

In general, the noble gases are chemically ___a___. In nature, they are ___b___ molecules, rather than ___c___ molecules like the halogens. ___d___ is the second most abundant element in the universe. The energy of the stars comes from the fusion of ___e___ into ___f___. The wavelength of the light of ___g___ has been used to define the international standard of the meter. ___h___ has the highest density of all gases.

a. UNREACTIVE
b. MONOATOMIC
c. DIATOMIC
d. Helium
e. HYDROGEN
f. HELIUM
g. KRYPTON
h. RADON